Exploration of Rice Bran (Pusa Basmati 1) for Nourishing & Therapeutic Potential and Harnessing it through Product Development Endeavours

A Synopsis

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Supervised By:

JV'n Dr. Nidhi Agarwal

Co-Supervised By:

JV'n Dr. Pramod K. Raghav

Submitted By:

JV'n Anshu Sharma
Enroll. No.: JVR-I/15/6008

Department of Agriculture, Food and Biotechnology

Faculty of Engineering and Technology

Jayoti Vidyapeeth Women's University, Jaipur (Rajasthan)

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INTRODUCTION:

Rice *(Oryza sativa)* is the most common staple food which is consumed by half of the World's human population. It is the 3rd highest agricultural commodity with the worldwide production after sugarcane and maize. Asia, Africa and America are the prominent rice producing continents. It is cultivated in 114 countries across the world.

Rice is grown as annual plant, besides it can also sustain as a perennial in tropical areas. It produces a ratoon crop for upto 30 years. The plant of rice grows tall upto 1-1.8 m (3.3-5.9 ft) which is more dependent on the variety of soil and its fertility. The leaves of rice plant are slender 50-100 cm (12-20 in) long and 2-2.5 cm (0.79-0.98 in) wide. The flowers are small wind-pollinated which produced in a branched arching to pendulous inflorescence 30-50 cm (12-20 in) long. The seed of edible part is a grain which is 5-12 mm (0.20-0.47 in) long and 2-3 mm (0.079-0.118 in) thick. High temperature above 20ºC but not more than 35-40ºC is required for rice cultivation (Rao, 2008).

SCIENTIFIC CLASSIFICATION OF RICE (http://plants.usda.gov/java/ClassificationServlet?source=displayandclassid=ORYZA)	
Kingdom	Plantae (Plants)
Subkingdom	Tracheobionta (Vascular Plants)
Superdivision	Spermatophyta (Seed Plants)
Division	Magnoliophyta (Flowering Plants
Class	Liliopsida (Monocotyledons)
Subclass	Commelinidae
Order	Cyperales
Family	Poaceae (Grass)
Genus	*Oryza*
Species	*Sativa*

Rice has two major subspecies: the sticky short grained *japonica or sinica* variety and the non-sticky, long grained *indica* variety. *Japonica* varieties are usually cultivated in dry fields, in temperate East Asia, upland areas of South East Asia and high elevations in South Asia, while indica varieties are mainly lowland rice grown mostly submerged, throughout tropical Asia (Molina et al., 2011). Rice endosperm (70%) is obtained as a major product while rice husk (20%), rice bran (8%) and rice germ (2%) are obtained as byproduct of rice milling industry which is obtained from the seed of the grass species of the *Oryza sativa* (Asian Rice) or *Oryza glaberrima* (African Rice) (Wells, 1993; Deckere and Korver, 1996; Hoed et al., 2006).

Pusa basmati 1 is a semi-dwarf plant which consists of almost all the features of traditional basmati including alkali content, grain elongation and rich fragrance. It is also known as "todal" because there are awns present in its flower. Pusa-1 basmati rice is one of the most demanded rice species all over the

world. Its maturity time is generally around 125 to 135 days and its average yield is 45 quintal/hectare. The grain size of Pusa basmati 1 is 7.2 mm when uncooked and 13.91 mm after cooking.

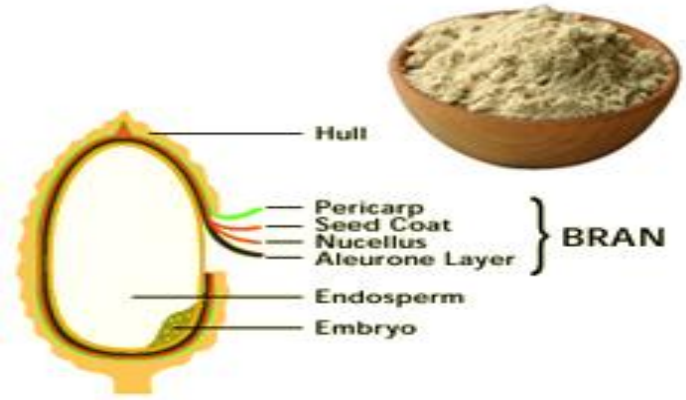

Fig. 1: Structure of Rice Bran
(http://modinaturals.com/image/brands_img/modi-images_oiltank.jpg)

Rice bran is the outer covering of rice kernel and consists of pericarp, aleurone, subaluerone layer, seed coat, nucellus, part of the germ and small part of starchy endosperm (Salunkhe et al., 1992; Hargrove, 1994). Rice bran is light in color, sweet in taste, moderately oily and has a slightly toasted nutty flavor (Hu et al., 1996). Rice bran has the appreciable amount of protein (11-17%), fat (12-22%), dietary fiber (6-14%) like β-glucan, pectin and gum; moisture (10-15%) and ash (8-17%). A major rice bran fraction contains 12-13 % oil and highly unsaponiable components (4.3%) (Saikia and Deka, 2011). Also it is rich in vitamins including vitamin E, thiamine, niacin, and minerals like aluminum, calcium, chlorine, iron, magnesium, manganese, phosphorus, potassium, zinc and sodium (Saunders, 1990 and Hu et al., 1996). Rice bran also contains phytochemicals with promising health benefits (Jariwalla, 2001). Its brighten prospects are the presence of antioxidants like tocopherol, tocotrienol, β-Sitosterol and γ-oryzanol for utilization of humans as functional ingredients to reduce the life threatening disorders (Gong and Yao, 2001; Moldenhauer et al., 2003).

Rice bran is rich in lipids and intense lipase activity in the presence of endogenous lipoxygenase causes rapid deterioration of these lipids by rancification (Paucer-Menacho et al., 2007). During the milling process, the oil and lipase in the bran come into mutual contact, resulting in the rapid hydrolysis of the triglycerides of the oil into glycerol and FFA. Such bran with higher amounts of FFA is unpalatable. The commercial use of rice bran requires enzymatic inactivation because of lipid susceptibility immediately after bran separation to avoid fatty acid liberation, allow its commercialization for human consumption and also to extend its shelf life.

OBJECTIVES:

The present research work has been planned to achieve the following objectives:

1. To evaluate the effect of processing on proximate principles of rice bran.
2. To estimate the minerals like iron, calcium of processed rice bran.
3. To assess the antioxidants and antinutrients of rice bran processed by various techniques.
4. To develop the value added food products by incorporating processed rice bran for different life stages from infancy to old age.
5. To develop the value added food products by incorporating processed rice bran for diseases like Constipation, Osteoporosis, Diabetes Mellitus (DM) and Cardiovascular Disease (CVD).

REVIEW OF LITERATURE:

The review of literature available pertaining to different aspects of the present research work has been studied under the following headings:

1. Rice Bran: An Overview.
2. Composition and Nutritive Value.
3. Processing of Rice Bran.
4. Health Benefits of Rice Bran.
5. Development of Food Products by Incorporation of Rice Bran.

1. Rice Bran: An Overview:

Salunkhe *et al.* (1992) and Hargrove (1994) investigated that rice bran is the outer covering of rice kernel and consists of pericarp, aleurone, subaluerone layer, seed coat, nucellus, part of the germ and small part of starchy endosperm.

Hu *et al.* (1996) concluded that rice bran is light in color, sweet in taste, moderately oily and has a slightly toasted nutty flavor.

Hoed *et al.* (2006) concluded that rice endosperm (70%) is obtained as a major product while rice husk (20%), rice bran (8%) and rice germ (2%) are obtained as byproduct of rice milling industry.

2. Composition and Nutritive Value:

According to Saunders (1990) and Hu *et al.* (1996), rice bran has the appreciable amount of protein (11-17%), fat (12-22%), dietary fiber (6-14%) like β-glucan, pectin and gum; moisture (10-15%) and ash (8-17%). Also it is rich in vitamins including vitamin E, thiamine, niacin, and minerals like aluminum, calcium, chlorine, iron, magnesium, manganese, phosphorus, potassium, sodium and zinc.

Gong and Yao (2001) and Moldenhauer *et al.* (2003) concluded that the presence of antioxidants like tocopherol, tocotrienol, β-sitosterol and γ-oryzanol is the brighten prospect of rice bran for utilization of humans as functional ingredients to reduce the life threatening disorders.

Ju and Vali (2005) depicted that rice bran contains a significant amount of nutraceutical compounds and approximately 4% unsaponifiable, mainly comprised of naturally occurring antioxidant such as tocopherols, tocotrienols and oryzanol.

According to Paucer-Menacho *et al.* (2007), rice bran is rich in lipids and intense lipase activity in the presence of endogenous lipoxygenase causes rapid deterioration of these lipids by rancification.

3. Processing of Rice Bran:

Khan *et al.* (2009) studied the antinutritional appraisal and protein extraction of differently stabilized rice bran. Rice bran from 'Basmati Super' cultivar was stabilized by dry heat, microwave heat and parboiling. Reduction of antinutrients including trypsin inhibitor, haemagglutinin-lectin and phytates were found in all stabilization techniques. Chemical composition of rice bran was also unchanged. Protein was extracted from differently stabilized rice bran along with unstabilized bran by enzymatic

extraction. Protein isolates yield remained highest for the unstabilized bran, followed by Microwave Stabilized Rice Bran Protein Isolates (MWRBPI), Dry Heat Stabilized Rice Bran Protein Isolates (DHRBPI) and Parboiled Rice Bran Protein Isolates (PAR-RBPI).

Ahmad *et al.* (2009) studied the nutritional content and storage stability of stabilized rice bran-MR 220. The nutritional composition of rice bran at 4% and 8% milling degree was stabilized by either autoclaving or parboiling process. The values of fat, fiber, ash, most minerals and vitamins in parboiled bran were generally higher than treatment by autoclave technique. The free fatty acid levels for both parboiled and autoclaved rice bran were below the 10% permissible level for 4 months and 6 months respectively for the product packed in oriented polypropylene/polypropylene packs, either vacuumed or without, and stored in ambient temperature room condition. The storage of rice bran by polypropylene packs, as control packaging material, led to rapid production of free fatty acids.

Faria *et al.* (2012) studied the nutritional composition of rice bran submitted to different stabilization procedures. Roasting on a conventional stove or heating in a microwave oven were applied. The different heat treatments affected sample composition, since the levels of some nutrients of treated samples showed significant changes ($P<0.05$) compared to corresponding raw samples. The rice bran treated on a conventional stove produced products with low moisture (5.14±0.10 g/100 g) and nutrients such as sodium 11.8%; palmitic acid 9.9% and stearic acid 8.1%. The microwave oven procedure resulted in better nutrient preservation, with slightly higher moisture content (6.28±0.10 g/100 g), and appeared to be a practical and rapid tool for heat stabilization of rice bran.

Bhosale and Vijayalakshmi (2015) revealed the processing and nutritional composition of rice bran. Processing was carried out by using microwave and probiotic treatment. Free fatty acid percentage of stabilized rice bran ranged from 4.10 to 7.50 from initial to 4^{th} week and in probiotic treated rice bran it was 4.35 to 7.95 upto 4^{th} weeks of storage period. Functional properties of rice bran like bulk density (0.22-0.38 g/ml), water absorption (2-3 ml/g), oil absorption (1.5-2.5 ml/g), water solubility (7.3-8.0%) and swelling power (6.7-7.2%) respectively were analyzed for stabilized and probiotic treated rice bran. Macronutrient composition of stabilized and probiotic treated rice bran were 4.30 and 5.40, 17.50 and 19.25, 13.10 and 17.20, 4.92 and 4.64, 52.33 and 48.55 g/100g respectively for moisture, protein, fat, ash and carbohydrate and it contained 7.85 and 4.96 g crude fiber, 21.17 and 13.10 g insoluble dietary fiber, 2.17 and 1.80 g soluble dietary fiber and 23.34 and 14.90 g total dietary fiber. Mineral content of stabilized and probiotic treated rice bran were 52.10 and 49.90, 1185.20 and 1186.50, 28.10 and 30.05, 6.02 and 5.89 mg/100 g for calcium, phosphorous, iron and zinc respectively.

4. <u>Health Benefits of Rice Bran</u>:

Qureshi *et al.* (2002) concluded the effect of stabilized rice bran, its soluble and fiber fractions on blood glucose levels and serum lipid parameters in human with diabetes mellitus Type 1 and Type 2. Two fractions of rice bran i.e. Rice Bran Water Soluble (RBWS) and Rice Bran Fiber Concentrates (RBFC) were made by treating stabilized rice bran (SRB) with carbohydrates and heat. These were fed to IDDM

and NIDDM patients for 60 days. The type I subjects (n=22, 26 and 20) fed SRB, RBWS and RBFC plus AHA Step I diet reduced glycosylated hemoglobin 1%, 11% and 10% respectively. The fasting Serum glucose levels were also reduced significantly (P<0.01) with SRB (9%), RBWS (29%) and RBFC (19%). The type II subjects (n=31 and 26) fed RBWS and RBFC plus AHA Step I diet reduced glycosylated hemoglobin 15% and 11% respectively. The fasting glucose levels were also reduced significantly (P<0.01 with RBWS (33%) and RBFC (22%). Serum insulin levels were increased (4%) with RBWS in both IDDM and NIDDM subjects. Serum total cholesterol, LDL-cholesterol, apolipoprotein B and triglycerides levels were reduced with RBFC in the type I (10, 16, 10, 7%) and type II groups (12, 15, 10, 8%) respectively. These results indicated that RBWS significantly reduced hyperglycemia (P<0.01), whereas RBFC reduced hyperlipidemia (P<0.05) in both types of diabetes.

Most *et al.* (2005) concluded that the rice bran oil, not fiber, lowers cholesterol in healthy, moderately hypercholesterolemic adults. In this study, defatted rice bran and rice bran oil were analyzed. Study 1 used a parallel-arm design. Twenty-six healthy volunteers consumed a diet with 13-22 g dietary fiber/day for 3 wk, and then 13 of the volunteers were switched to a diet with defatted rice bran to double the fiber intake for 5 wk. Study 2 was a randomized, crossover, 10 wk feeding study performed in 14 volunteers who consumed a diet with rice bran oil (1/3 of the total dietary fat) substituted for an oil blend that had a fatty acid composition similar to that of the rice bran oil. In both the studies serum lipids and factor VII were measured. Defatted rice bran did not lower lipid concentrations. In study 2, total cholesterol was significantly lower with consumption of the diet containing rice bran oil than with consumption of the control diet. Moreover, with consumption of the rice bran oil diet, LDL cholesterol decreased by 7% (P <0.0004), whereas HDL cholesterol was unchanged.

Tazakori *et al.* (2007) determined the effect of rice bran powder on blood glucose levels and serum lipid parameters in type 2 diabetic patients. This study was Double Blind non cross-over Trial 60 Diabetic Patient which hadn't renal and liver disorder and high hypertension after physical exam selected and then randomly divided to two intervention and control group first group intake 10 g soluble rice bran 2 period a day (at morning and before sleeping) and second group intake placebo blood glucose and plasma lipids levels were determined before and after study The data were analyzed by paired t-test and ANOVA, using SPSS and Food processor. The fasting serum Glucose level and 2 h after eating were reduced significantly (P<0.001). Triglyceride levels were reduced (P<0.01) and HDL were increased significantly too (P<0.05).LDL and cholesterol had reduced too but not significant (P>0.05).

5. <u>Development of Food Products by Incorporation of Rice Bran</u>:

Premakumari *et al.* (2012) studied the development of breakfast/dinner recipes by substituting cereals with rice bran at different levels and determined the acceptability of the food mixes. Stabilization studies revealed that moisture and free fatty acid content was lower in microwave stabilized parboiled rice bran and hence considered ideal for product development. Ten standard Indian subcontinent breakfast/dinner recipes namely chapatti, mixed vegetable chapatti, wheat dosa, wheat rava idli, adai, rava adai, ragi adai,

rice vermicelli, ragi vermicelli and kolukattai were chosen for incorporating rice bran at 25, 30 and 35 per cent by replacing the cereals and pulses in the standard recipe. The acceptability trials were carried out using 20 semi trained panel members. The results revealed that the recipes with 25 per cent incorporation of rice bran had a good acceptability in par with standard recipe.

Singh *et al.* (2013) investigated the utilization of rice bran for the development of value added Indian sweet. Besan ladoo was standardized as Control (T_0) and then incorporation of rice bran in place of besan at different percentage (10%, 20% and 30%) was done to get T_1, T_2 and T_3 treatments respectively. Significant difference was found in the organoleptic characteristics between T_0 and T_3 whereas non-significant difference was found in T_0 and T_1 except in case of texture.

Singh *et al.* (2013) investigated the utilization of rice bran for the development of chapatties and its glycemic response in NIDDM patients. In the wheat chapatti, rice bran was incorporated at 20 percent level. Its nutritive value, organoleptic evaluation, glycemic index (GI) and glycemic load (GL) were calculated. Total 20 subjects, 16 males and 4 females were selected with average age and BMI of 56.55±6.37 and 26±3.68 respectively. Overall acceptability scores were in acceptable range for controlled chapatti (8.99) and rice bran based chapatti (8.08). The GI of rice bran based chapatti (68.34±11.49) was significantly lower ($P \leq 0.01$) than controlled chapatti (83.92±9.63). The peak blood glucose was found between 60-90 minutes of reference and both type of chapattis, however the mean blood glucose concentration was found lowest for rice bran chapatti.

Bhosale *et al.* (2015) revealed the processing of rice bran and its utilization in food products. The stabilization of rice bran was done by microwave heating and stabilized rice bran was inoculated with Lactic acid Bacillus culture and used as probiotic treated rice bran. Microwave stabilized and probiotic treated rice bran were analyzed for free fatty acid percentage, macronutrient composition and mineral content. Biscuit and bread, the two products were developed. The processed rice bran was incorporated at 5 to 15% levels. Both the products were analyzed for functional properties. Organoleptic evaluation of the products showed that bread was best accepted at SRB 5% and PRB 10% and biscuits were best accepted at SRB 10% and PRB 10% respectively.

MATERIALS & METHODS:

The present study will be conducted in the three phases. These are:

⇒ **PHASE-I: Preparation of processed versions and their analyses.**

- **Processed Versions:** Rice bran will be procured from ICAR, New Delhi:

1. **Rice Bran (RB):** It will be an unprocessed sample without any heat treatment.
2. **Autoclaved Rice Bran (ARB):** Rice bran will be autoclaved at 120°C for 20 min. Then autoclaved rice bran will be dried at 60°C to reduce the moisture content to less than 5% (Ahmad et al., 2009).
3. **Microwave Processed Rice Bran (MPRB):** Moisture content of the raw rice will be first adjusted to 20% by adding deionized water. 100 g sample of rice bran will be taken and microwave stabilization will be done at 2450 MHz for 3 min (Bhosale and Vijayalakshmi, 2015).
4. **Pan Roasted Rice Bran (PRRB):** 100 g rice bran will be heated in stainless steel pot at 80°C for 6 min (Faria et al., 2012).
5. **Parboiled Rice Bran (PBRB):** Paddy of rice will be soaked for 8 h at 60°C, steaming at 6.5 PSI at 120°C for 10 min in autoclave followed by drying in aluminum trays at ambient temperature to final 12-13% moisture content. Bran will be obtained from parboiled paddy (Biswas and Juliano, 1988).
6. **Hot Air Oven Processed Rice Bran (HAOPRB):** 100 g of rice bran will be taken and subjected to 130°C for 20 min (Bagchi et al., 2014).

- **Analyses:**

1. **Proximate Principles:** All determinations for proximate composition of processed rice bran will be done by following the AOAC (2000) official protocols. These are:

- **Moisture:** Moisture will be determined from sample weight loss after drying at 105°C until constant weight (AOAC, 2000).
- **Protein:** Protein content will be determined by Kjeldahl method which involved protein digestion and distillation. The protein content will be obtained by multiplying the nitrogen value with 6.25 (AOAC, 2000).
- **Fat:** Total fat will be determined by Soxhlet extraction method using petroleum ether as a solvent (AOAC, 2000).
- **Ash:** Total ash will be determined by Muffle Furnace Incineration based on the vaporization of water and volatiles with burning organic substances in the presence of oxygen in the air to CO_2 at a temperature of 600°C (dry ashing) (AOAC, 2000).
- **Crude Fiber:** Crude fiber will be obtained after digesting the sample with diluted acid, alkali and alcohol (AOAC, 2000).

- **Carbohydrates:** Carbohydrate will be calculated by difference method i.e. by subtracting from 100 the sum of the value (per 100 g) for moisture, protein, fat, ash, crude fiber (AOAC, 2000**)**.

2. Minerals:

- **Iron:** Iron contents will be determined by converting the iron to ferric form using oxidizing agents' potassium persulphate and hydrogen peroxide and treating thereafter with potassium thiocyanate to form the red ferric thiocyanate which is measured colorimetrically at 480 nm (Wong, 1928).
- **Calcium:** Calcium content of processed rice bran will be determined by titration with a solution of potassium permanganate (Hawk et al., 1957).

3. Antioxidants:

- **Antioxidant Activity:** The antioxidant activity of rice bran will be determined by DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging capacity**.** The mixture containing the DPPH turns from deep violet to a yellow solution, higher the antioxidant activity faster is the discoloration rate. The absorption will be measured using a spectrophotometer at 515 nm which gives the per cent inhibition of the sample (Miliauskas et al., 2004).
- **Tocopherol:** Tocopherol will be determined by TLC method in which tocopherol reduces ferric ion to ferrous ion quantitatively, which then combines with bathophenanthroline to an orange coloured complex which will be read at 534 nm (Kayden et al., 1973).
- **Oryzanol:** The analysis of gamma-oryzanol will be performed using the reversed phase high performance liquid chromatography (RP-HPLC). The gamma-oryzanol will be detected at 325 nm. Chromatograms will be recorded, and peak areas will be used to calculate the content of gamma-oryzanol compared with those of standards. (Chen and Bergman, 2005)

4. Antinutrients: Antinutrients pose risk associated with rice bran. The bran samples will be uniformly mixed with 20% (w/w) solution of 1% calcium hydroxide to analyze the anti-nutrient. Analyses will be carried out for trypsin inhibitor and phytates as follows:

- **Trypsin inhibitor activity:** Bran sample will be blended with 0.05N HCl. The extracted slurry will be centrifuged and Trichloroacetic Acid (TCA) is added to the supernatant and re-centrifuged. After neutralization the enzyme inhibitory activities will be determined (Decker, 1977).
- **Phytic Acid:** Phytic acid content will be determined by the following method which is based on indirect iron (III) complexometry; it uses sulfosalicylic acid as an indicator of the titration endpoint (García-Villanova et al., 1982).

⇒ PHASE-II:

- **Selection and Procurement:** The different food products will be selected according to the suitability and nutritional needs of different life stages i.e. infancy to old age and different diseases like constipation, osteoporosis, diabetes mellitus and cardiovascular diseases.
- **Standardization of products:** All food products will be standardized after a number of trials in laboratory.
- **Incorporation of processed versions:** Different processed versions like ARB, HAOPRB, MPRB, PRRB and PBRB will be incorporated in food products to make the healthy and nutritious food products.
- **Organoleptic evaluation:** Organoleptic evaluation will be done by nine point hedonic test (Srilakshmi, 2010).

⇒ PHASE-III:

- **Statistical Analyses:** Significant difference and Analysis of variance among means will be tested by 't' test and ANOVA test in triplicates.

1. **Mean:** The mean is the mathematical average of a set of numbers. The average is calculated by adding up two or more scores and dividing the total by the number of scores.
2. **Standard Deviation (SD):** Standard deviation is the measure of the dispersion of a set of data from its mean. Standard deviation is calculated as the square root of variance.
3. **Student's 't' test and ANOVA:** The t-test will be used to test the significance of the difference between two samples means and the analysis of variance (ANOVA) will be used to determine whether there are any significant differences between the means of three or more independent (unrelated) groups. It is the separation of variances ascribable to one group of causes from the variances ascribable to other groups.

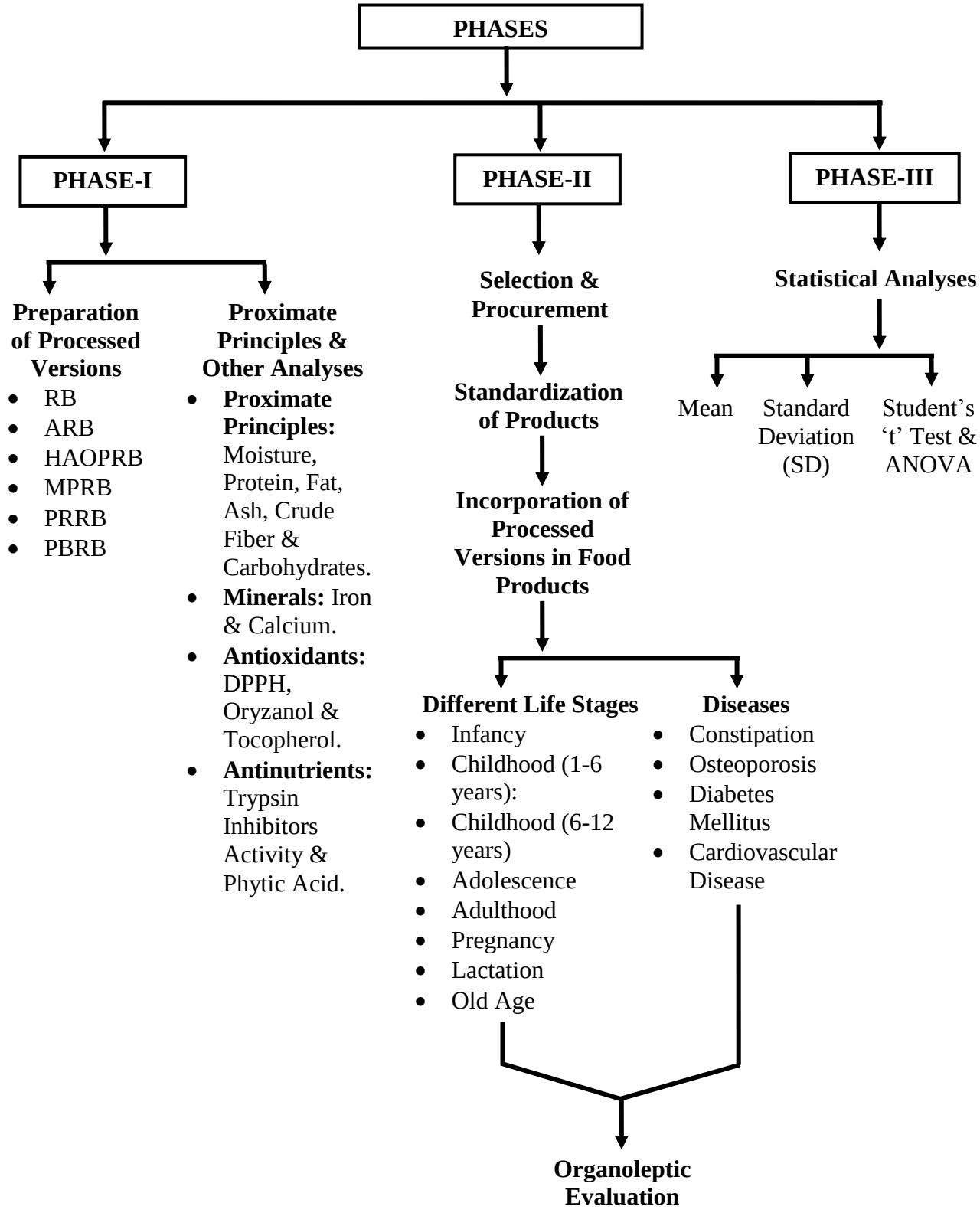

Fig. 2: Methodology of the Proposed Research Work at a Glance

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